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Global Climate Change, Food Security and the U.S. Food System

Expert Stakeholder and Author Meeting
Workshop Report (25-27 June 2013)

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Expert Stakeholder Workshop for the USDA Technical Report on Global Climate Change, Food Security, and the U.S. Food System

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Reston, VA**

Meeting organizers: Molly Brown, Peter Backlund, Rachel Hauser, Jenna Jadin, Anthony Murray, Paula Robinson, and Margaret Walsh

Major Meeting Themes

Climate change influences on the major pillars of food security. Each of the four elements of food security (availability, access, utilization, and stability) is vulnerable to changes in climate. For example, reductions in production related to regional drought influence food availability at multiple scales. Changes in price influences the ability of certain populations to purchase food (access). Utilization may be affected when production zones shift, reducing the availability of preferred or culturally appropriate types of food within a region. Stability of the food supply may be highly uncertain given an increased incidence of extreme climatic events and their influence on production patterns.

Data and analytical frameworks. Much has been written regarding climate change's relationship to food security. However, that literature has been largely conceptual in nature, with few analytical frameworks available to examine the relationship quantitatively at geographic and temporal scales for application by programmatic professionals in the field working to reduce food insecurity. Connecting global food security frameworks to the climate vulnerability of the U.S. food system requires datasets with similar conceptual foundations. While improved data, models, and other types of information that allow scientists to project outcomes of changes in climate to agricultural production (availability) are needed, more is currently available in this area of food security than for its other elements – access, utilization, or stability. Limited analytical capacity currently exists relating climate change's relationship to food systems, more broadly, and to U.S. food systems specifically.

International perspective. U.S. agriculture and the U.S. food system are vulnerable to climate change effects in other parts of world. Changes in the frequency and intensity of droughts, floods, and other types of extreme weather globally will not only affect imports into the United States, but are also likely to influence exports through global food demand and pricing.

Questions of food security, therefore, are global in nature and cannot be understood at the national scale without factoring in global forces.

Weather extremes. Weather extremes, rather than a gradual change in temperature or precipitation, have posed the most recognizable challenges to the food system in recent years, and are likely to become even more important in the future. Climate variability is a source of both risk and opportunity for agricultural households, as they can take advantage of good weather years to improve food security during bad weather years. Weather extremes can also pose large-scale risk to society that can cascade across multiple economic sectors in unforeseen ways, causing food insecurity and hardship that can degrade development gains. Both the likelihood of extreme events and adaptation practices – be they biophysical or institutional – affect farmers and food insecure people.

1.0 Introduction

The United States Department of Agriculture (USDA), with help from the National Center for Atmospheric Research (NCAR), hosted a workshop on Climate Change and Global Food Security on June 25-27, 2013 in Reston, Virginia.¹ The workshop was held as part of the process of writing a USDA Technical Report on the effects of climate change on global food security, and how these changes might affect global and U.S. food systems. The workshop was designed to develop a baseline for understanding the issues, identify some of the threats and opportunities posed by climate change to global food security, and get expert input on the topical scope of the USDA technical report. The workshop included 29 participants with expertise across a range of disciplines. Participants represented federal, state, and local government, non-governmental organizations, industry, and academia. The two-day event fostered dialog among the authors and subject matter experts in climate change, food security, and related areas, with stakeholders providing input on their priorities and analytical needs. The report authors will use this feedback, factoring those interests and topics into the technical report to the degree both technically and practicably feasible.

This summary document provides a general overview of the climate change-food security intersection. In addition, it offers a synopsis of the presentations by workshop participants on food security, food systems, and climate change. As part of the meeting, participants were asked to share their expert opinions regarding the likely effects of changing climate on food security and systems regionally, nationally, and globally.

¹ A list of attendees in Appendix A.

2.0 The Intersection of Climate Change, Global Food Security, and Food Systems

The 2006 United Nations Food and Agriculture Organization (FAO) defines food security² as having been achieved when all people at all times have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life, and is composed of four fundamental elements (see Box 1). Achieving global food security in the face of growing environmental and socio-economic change is amongst society's greatest challenges. The United Nations estimates that by 2050 the world will need to find a way to feed more than nine billion people – approximately two billion more than live on the planet today. Economic, social, biophysical, technological, and institutional drivers of current and future global food security, as well as the environmental constraints affecting each of these areas and the global food system, are all important, interdependent considerations.

Box 1. The Four Fundamental Elements of Food Security

- Availability – the availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).
- Access – access by individuals to adequate resources for acquiring appropriate foods for a nutritious diet.
- Utilization – utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional wellbeing where all physiological needs are met.
- Stability – to be food secure, a population, household, or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks or cyclical events.

In a recently published USDA Technical Report³ that assessed how climate change is affecting U.S. agriculture, increasing atmospheric carbon dioxide (CO₂), rising temperatures, and altered precipitation patterns were found to have notable effects on the nation's agricultural productivity. The report authors found that increases in temperature, coupled with more variable precipitation, will reduce productivity of crops, with these effects outweighing any benefits of increasing CO₂. Climate change, however, is an issue affecting not just U.S.

² FAO Food Policy Brief, 2006. Food Security. AO's Agriculture and Development Economics Division (ESA) with support from the FAO Netherlands Partnership Programme (FNPP) and the EC-FAO Food Security Programme. ftp://ftp.fao.org/es/ESA/policybriefs/pb_02.pdf

³ Walthall, C.L., J. Hatfield, P. Backlund, L. Lengnick, E. Marshall, M. Walsh, S. Adkins, M. Aillery, E.A. Ainsworth, C. Ammann, C.J. Anderson, I. Bartomeus, L.H. Baumgard, F. Booker, B. Bradley, D.M. Blumenthal, J. Bunce, K. Burkey, S.M. Dabney, J.A. Delgado, J. Dukes, A. Funk, K. Garrett, M. Glenn, D.A. Grantz, D. Goodrich, S. Hu, R.C. Izaurralde, R.A.C. Jones, S-H. Kim, A.D.B. Leaky, K. Lewers, T.L. Mader, A. McClung, J. Morgan, D.J. Muth, M. Nearing, D.M. Oosterhuis, D. Ort, C. Parmesan, W.T. Pettigrew, W. Polley, R. Rader, C. Rice, M. Rivington, E. Rosskopf, W.A. Salas, L.E. Sollenberger, R. Srygley, C. Stöckle, E.S. Takle, D. Timlin, J.W. White, R. Winfree, L. Wright-Morton, L.H. Ziska. 2012. Climate Change and Agriculture in the United States: Effects and Adaptation. USDA Technical Bulletin 1935. Washington, DC. 186 pages.

agricultural productivity and agro-ecosystems. It is altering agricultural and food production systems worldwide, and influences each of the four food-security elements beyond production considerations alone. These changes are having repercussions on global food security, and will continue to do so as the global climate continues to react to the effects of increasing atmospheric greenhouse gas concentrations.

Box 2. Global Effects of Climate Change

Human influences will continue to alter Earth's climate throughout the 21st century. Current scientific understanding, supported by a large body of observational and modeling results, indicates that continued changes in atmospheric composition will result in further increases in global average temperature, changes in precipitation patterns, rising sea level, changes in weather extremes, and continued declines in snow cover, land ice, and sea ice extent, among other effects that will affect U.S. and global agricultural systems.

While climate change effects vary between regions, among annual and perennial crops, and across livestock types, all production systems will be affected to some degree by climate change. Temperature increases coupled with more variable precipitation will reduce crop productivity and increase stress on livestock production systems. Extreme climate conditions, including dry spells, sustained droughts, and heat waves will increasingly affect agricultural productivity and profitability. Climate change also exacerbates indirect biotic stresses on agricultural plants and animals. Changing pressures associated with weeds, diseases, and insect pests, together with potential changes in timing and coincidence of pollinator lifecycles, will affect growth and yields. When occurring in combination, climate change-driven effects may not simply be additive, but can also amplify the effects of other stresses on agroecosystems.

With ever tighter global linkages, events and crises affecting the global food system are increasingly influencing U.S. food systems. Various components of the global food system are vulnerable to weather extremes, which a changing climate is exacerbating. Extreme weather events can lead to disruptions within the food system. Further adding to food system pressures is the growing demand from emerging middle-income consumers who, with additional wealth, are changing consumption patterns. With more demands placed on global production systems and greater likelihood of extreme weather events, the probability of market volatility grows. When market volatility occurs in combination with other social or political disturbances, disruptions in global, national, and regional food systems may be exacerbated; this ultimately affects food security. While emerging middle-income nations and individuals on average can more easily withstand the effects of higher food costs, volatile markets and weather still have the capability of adversely affecting vulnerable populations.

Box 3. Food Systems

Food systems encompass 1) activities related to the production, processing, distribution, preparation and consumption of food; and 2) the outcomes of these activities contributing to food security (food availability, with elements related to production, distribution and exchange; food access, with elements related to affordability, allocation and preference; and food use, with elements related to nutritional value, social value and food safety). The outcomes also contribute to environmental and other securities (e.g., income). Interactions between and within biogeophysical and human environments influence both the activities and the outcomes.

2.1 Technical Report Guiding Principles

Certain guidelines had already been determined for the report prior to the Workshop. The report will identify some of the current issues and research on the effects of climate change on global food security, and how these outcomes might affect national and global food systems. Additionally, the technical report will use the present day state of the climate and food security as a baseline for developing projections of the trends and outcomes of climate change on food security that will occur in the near-term (i.e., the next 25 years) and over the longer term (i.e., 100 years). The report will not provide policy prescriptions; instead it will report on the current and possible future state of food security and global and U.S. food systems, factoring in the effects of climate change.

3.0 Background Information: Presentations on Climate Change and Food Security

The workshop consisted of two types of presentations: Informational background regarding the nature of food security, the science of climate change, and what is currently known about the relationship between the two topics. The second type of presentations came from stakeholders, to discuss important analytical gaps for operational purposes. The following sections of this summary highlight each. The summaries describe the material presented and are the opinions of the presenters. Moreover, the priorities reported do not represent a mandate for the *Climate Change, Global Food Security, and the U.S. Food System* report.

3.1 Molly Brown: What is Food Security?

Food security ties directly to the availability, access, utilization, and stability of a food supply. However, how each of these characteristics of food security manifests typically varies, depending on geographic scale. For instance, household food security may be most affected by income, whereas national food security is driven by a nation's ability to produce or import food, or weather extremes, while global food security is affected by large-scale land and water constraints, political stability across nations, global-scale weather extremes, etc. As a result, information requirements for analyzing issues that affect each level of food security also differ greatly. Scale- and context-relevant information are necessary for fully understanding how food supplies and security may be affected by changing climate.

Socio-economic factors are also relevant. Wealthy, middle income, and poor or agriculture-dependent populations will experience different vulnerabilities to extreme weather events, with

household, regional, and national income notably affecting regional food security and food demand. Nations transitioning from agricultural to industrial and service economies, and growing urban areas may be influenced differently by changes in climate. National priorities for balancing food security with greenhouse gas emissions from energy, development, and urbanization, versus energy conservation will also influence outcomes.

3.2 Stacey Rosen: Assessing Food Security

Models are important tools for assessing food security. The USDA Economic Research Service's (ERS) annual report, the *International Food Security Assessment* (IFSA), describes factors affecting food consumption and gaps in the per capita nutrition target using the ERS IFSA model. IFSA provides current estimates and future projections of food availability and access in 76 countries in four world regions, including sub-Saharan Africa, Asia, Latin America and the Caribbean, and North Africa. IFSA relies on food security indicators to identify gaps in average nutritional targets (nutritional gap) and the food gap associated with unequal purchasing power or food access (distributional gap).

Analytical tools, such as IFSA, are essential for providing comparative metrics that answer the question, 'Which counties are prone to food insecurity?' However, like all analyses on food security, the approach is constrained by data availability and reliability.

3.3 Peter Backlund: Climate Change, its Effects on Agriculture, and Land-Use Considerations

Climate change is the significant and lasting change in the statistical distribution of weather patterns over periods ranging from weeks to decades or longer. It reflects changes in average weather conditions or in the distribution of weather around the average conditions (i.e., more or fewer extreme weather events). Current understanding of how increasing atmospheric greenhouse gases affect average temperature is far greater than understanding of precipitation changes, although shifts in temperature, precipitation, and water resources (among other effects) resulting from climate change are becoming more evident.

Climate change will have a number of effects on agriculture, including:

- **Direct effects** from changes in temperature, precipitation, and CO₂ concentrations. For example, with increasing average air temperatures, crop water demands will likely increase, as will stresses on livestock. In some regions, precipitation intensity will increase, affecting soil erosion, decreasing soil quality, and reducing young plant survival, among other issues. Also, incidence of weather extremes will increasingly affect agricultural systems, with higher incidence of hot nights, increasing incidence of extreme storms, and with changes in the maximum number of consecutive dry days and temperature extremes.
- **Indirect effects** include changes in weed, disease, and insect populations and distributions. For example, C₃ plants, which include most weeds, tend to respond well to increasing CO₂. Increased populations and northward expansion of weeds are predicted, which will increase costs of managing pests and increase crop losses. Additionally, increasing drought incidence can disrupt the biotic resistance of native species, while fire will favor succession and survival of invasive species.

Among the topics to consider with regard to effects of climate change on agriculture are:

- Whether the rate of adaptation within the agroecosystem and food production systems will keep up with the rate of climate change, and how will these adaptive responses affect global food security?
- Will climate change reduce or expand agricultural lands? Where?
- How will regional climate change affect regional, national, and global food security? E.g., changes in temperature and precipitation may favor some regions and harm others.
- How will climate change affect marine ecosystems and marine ecosystem productivity regionally? Globally?
- How will climate change affect other aspects of food security and the food system beyond production (e.g., harvesting, processing, transportation)?
- How will the climate change over the next century?
- Can we increase capacity to adapt to climate? Is climate change mitigation possible while improving food security?

3.4 Molly Brown: Connecting Food Prices to Environmental Dynamics

Food prices, whether rising, falling, or remaining stable, offer insights on urban food security. While climate change-driven events are certainly not the only effects that influence food prices, they affect global, national, and regional food price spikes, which, in turn, affect food security. Food price volatility and its links to environmental change provide insight on the effects of climate change on food security.

Food-price time series support diagnoses of the effects of local food production variability and global economic food price trends on food access in specific markets by enabling a quantification of the vulnerability of particular communities to large-scale changes in productive capacity due to effects of changing climate. Availability of food price information is on the rise: 956 data time series now span approximately 10 years and may be used operationally to understand food access across many different countries.

In regions or nations where few or no measures of trade are available – predominantly in food-insecure regions – satellite data may be used to estimate food production in economic models. Satellite images provide critical information on production and production variability by allowing analysis of spatially explicit anomalies resulting from weather variability. This information, when merged with food prices and other relevant economic model data, helps to improve understanding of food prices and how food markets are working.

3.5 Hector Maletta: The Geography and Related Driving Factors of Food Security

Humans have an extraordinary adaptive capacity in the face of changing situations and environments. This trait may be heightened in the case of agricultural producers, who universally react to their environment and modify practices as situations demand. Understanding how current populations around the world are adapting to changing climate and other socio-economic and environmental discontinuities, and projecting how adaptation might look in future, may assist in understanding future resilience to climate change and the effects of adaptive capacity and solutions on regional, national, and global food security, food production, and food systems. This said, some imagination may be necessary in considering future adaptive trends; the notion that producers will continue forever with current practices into the future may offer a compelling, but likely overly simplistic assumption.

Changes to farming systems and technology are already observable under changing climate; however not every change can be predicted and adaptation strategies may not always be effective. Given the difficulty of projecting both the socio-economic context and the future behavior of agricultural producers in response to climate change, many scientists turn to socio-economic scenarios to estimate the co-varying drivers that will affect the future vulnerabilities of food producers and systems into the future. Such scenarios require estimates of future population levels, economic activity, the structure of governance, social values, patterns of technological change, and projections of future climate. Economic and integrated assessment modeling can be used to analyze and quantify the effects of such drivers.

3.6 John Reilly: Pathways of Future Development

A major challenge for developing the 25- and 100-year future scenarios is that trade, which is important to food security and food system dynamics, is often poorly represented in current modeling frameworks and difficult to project into the future. How trade affects the world and how these effects are reflected globally are important considerations. Other environmental and resource issues, as well as competition for land, will be valuable to represent in scenarios. While climate change is certain, uncertainty exists about the specific responses of the Earth system to changing climate and how these changes will affect food security. Finally, uncertainties exist related to agriculture (e.g., yield growth, water availability, willingness to convert new land to crops, dietary changes, crop and livestock response to climate, and environment change). In addition, policies, economic growth and other trends factor into analytical approaches. Mitigation and adaptation activities also influence potential future food security outcomes.

3.7 Jean Buzby: Food Loss and Food Waste

Food loss and food waste occur frequently, but often are a routine part of life and doing business and so do not always rise to the level of recognition of other food security issues. Food loss represents the edible amount of food, pre- and post-harvest, available for human consumption that is not consumed for any reason. Food loss includes cooking loss and natural shrinkage (for example, moisture loss from food), loss from mold, pests, inadequate climate control, and food waste. Food waste occurs when an edible item goes unconsumed, as in food that is discarded by retailers due to objectionable color or appearance, or plate waste by consumers. Food waste and loss are relevant for a variety of reasons:

- More food will be needed as global population expands.
- Decomposing food produces methane, a greenhouse gas, as part of the decomposition process.
- Food loss represents significant wasted investment.

Food waste in the developed world is not insignificant, far exceeding that which occurs in developing nations. In Europe and North America annual, per capita waste is 95-115 kg/year, whereas in sub-Saharan Africa and South/Southeast Asia waste accounts for 6-11 kg/year. In developing countries a variety of food loss issues exist. These include problems with storage, limited markets, and poor transportation infrastructure. Understanding the reasons for food loss and identifying methods to reduce waste and loss in developing and developed countries – e.g., conserving scarce resources such as water or fragile ecosystems – will be useful to bring to light and factor in to the larger food security picture.

3.8 Bill Easterling: Food Aid and Climate Change

Millions of the global poor are at risk of hunger under changing climate in the next 25 to 100 years. Understanding where the regions with the most need are will be important to making food aid decisions; food aid is the voluntary transfer of resources from one country to another. Regions of Africa are expected to experience the greatest need during the next century. Declining per capita production in sub-Saharan Africa will likely make regional trade an increasingly important means for ensuring adequate food provision, as well as a focus for international food aid.

For reasons of increased efficiency under changing climate conditions, U.S. decision makers may have to develop new ways of delivering aid. The U.S. tends to buy food from domestic producers, transporting these goods to recipient countries, which then distribute the food to target audiences. Only US\$0.40 on every dollar goes to food production, the rest covers shipping, administration, and other expenses. Additionally, when food prices are kept artificially low, poor countries have become significant food importers, resulting in a decrease in social welfare when subsidized prices are removed. Understanding the nuances of the effects of U.S. aid may benefit from being articulated.

In a world of constrained resources, climate change response priorities will need to be identified. Increasing incidence of extreme events, increased population numbers, and a reasonable reprogramming of assets will serve to increase the need for food aid. The humanitarian community seeks effective tools to transfer climate risk and to enable affordable social safety nets.

4.0 Case Studies and Stakeholder Perspectives

Stakeholders offered the authors input and advice regarding useful outcomes for the *Global Climate Change, Food Security, and the U.S. Food System* report. Some of these perspectives are captured in the following sections. While the authors turned to stakeholders to gather expert input on identifying important topical areas, the opinions below are those of the presenters, and do not represent a mandate for the report.

4.1 Ana Rios: Inter-American Development Bank

The Inter-American Development Bank (IDB) serves Latin America and Caribbean (LAC) economies spending one out of every four dollars on climate change and adaptation in the agricultural, land use, and forestry sectors in these regions. Recent work of the IDB has been to measure the effects of climate change, noting related adaptation measures. In a recent report, the IDB notes that the effect of climate change on the agriculture sector is only measured by loss in net exports of wheat, soybean, maize, and rice. The report estimates \$26-44 billion in climate change-related losses occurring by 2050 if climate change remains unaddressed. Additionally, glacier retreat (\$22 billion) and coral bleaching (\$8 billion) contribute to the total economic damage of \$100 billion for the regions served by the IDB. However, costs of adaptation are estimated to be no more than \$25 billion, with many of these adaptive measures benefitting regional food security.

Most research on climate change effects in the regions served by the IDB has focused on the consequences of ambient air temperatures; however for small and vulnerable countries like the

Dominican Republic and those in Central America, more detailed information on the regional effects of climate change would be beneficial. For instance, understanding the interactions between higher temperatures and changes in rainfall, or potential changes in soil temperature, which affects plant germination and growth, would be useful information for IDB's constituents. Rios also pointed to the benefits of performing analyses examining the connections between food security effects, poverty, and children. Many of these areas might be of interest to other stakeholders if explored in greater detail in the USDA technical report.

4.3 Brian Peniston: Food Security in Nepal

Half of the world's biodiversity hot spots are located in the world's mountainous regions. These areas are often also home to indigenous people who are particularly vulnerable to climate change and food insecurity. Nepal offers an example of both, and is a low-ranking nation on human development indices, with an estimated 50% of the nation's 27 million inhabitants experiencing malnutrition. Eighty-five percent of the population works as agricultural producers, under generally challenging food production conditions in a geography marked by steep slopes, degraded soils, and extreme weather.

Among its other efforts, the UN World Food Programme has a protracted relief and recovery program in the poor northwestern region of Nepal. Using a food-for-work approach, food is provided in exchange for unskilled labor that supports and enhances community farming and climate resilience in a variety of ways, such as paving of trails with stone, changing water flows in vulnerable streams, and improving community forest resources. This aid program provides a 'triple win' of using food to feed hungry people, creating employment in an underemployed area, and creating community assets. However, the program has some limitations because people are limited to small projects, and while this aid program addresses the nation's immediate, chronic hunger, significant risk exists of creating aid dependency. Additionally, an inherent contradiction exists in that by giving people food for not producing food, it may become harder to use community projects to produce food. The USDA assessment might explore the effects of food security on the agriculturally dependent to provide more information on what these populations might expect in future.

4.4 Mike Budde: An Overview of the Famine Early Warning Systems Network (FEWS NET)

The Famine Early Warning Systems Network (FEWS NET) is a USAid-funded activity that collaborates with international, regional, and national partners to provide timely and rigorous early warning and vulnerability information on emerging and evolving food security issues. FEWS NET uses a suite of communications and decision support products to help decision makers mitigate food insecurity. These products include monthly food security updates for 25 countries, regular food security outlooks and alerts, as well as briefings and support to contingency and response planning efforts. More in-depth studies in areas such as livelihoods and markets provide additional information to support analysis as well as program and policy development. FEWS NET teams recently began assessing effects of global and regional climate change, identifying locations with greatest needs and times when outcomes will have greatest effect on livelihoods and seek to inform where adaptation is needed. Metrics for validation of the utility of FEWS NET tools and capabilities are desirable to support anecdotal stories of improvements to understanding of global and regional food security, particularly in areas lacking on-the-ground FEWS NET members.

4.5 Martha Schlicher: Industry Perspective on the Effects of Climate Change on Agriculture

Increased agricultural productivity has gone global, with technology fostering the expansion of row-crop production around the world at a faster rate than in the United States. These advances are due to information sharing and practices that optimize available technologies, including adoption of hybrids, optimization of planting, and use of genomics that are pushing yield advances forward. Increased productivity has resulted in the U.S. market-share mattering less in the global marketplace.

Despite these advances, under changing climate, industry experts are not banking on sustaining current productivity levels. This is the case in part because model projections do not generally include climatic extremes, and follow current production trends and existing annual variability. While plants that flourish in warmer climates are being introduced into new breeding programs even as climate changes are occurring, industry scientists are unsure if it will be possible to breed plants to withstand a 4-degree Celsius temperature increase. Agricultural producers are adapting to new extremes by choosing different, more stress- and disease-resistant breeds, as well as by improving soil conservation and irrigation practices and changing timing of planting.

Among the concerns of the agricultural industry and producers is ensuring that regions are not limited to growing a single crop; crop diversity seems likely to be an important consideration under future climate conditions. Additionally, increasing pest pressure is likely. Not enough work is currently going into addressing this in the timeframe needed for solutions. As temperatures rise, forests will be susceptible to foliage-eating insects, which may lead to increased regional temperatures generally, which will affect corn and other crops.

4.6 Christopher Delgado: A World Bank Perspective on Agriculture and Resilience Under Changing Climate

The World Bank's core business is people and addressing poverty, with interest in agricultural development only as it applies to dealing with poverty issues. This issue is huge, with three quarters of the world's poor living in rural areas – areas in which land and water resources are typically degrading. In the past, a small group of nations helped the global poor directly during food and financial crises, however, these nations are less able to do this now, and many more decision makers are now involved in the conversation related to food.

Climate change is expected to lower yields by 5% per degree Celsius change. Already aware of some of the effects of climate change, decision makers understand that intensification on current cropland will have to provide the additional yield required, but more water will be needed. Already, work is being done on adapting to climate change – mitigation is not typically a focus. Adaptation increases farm productivity, increases incomes, and addresses climate adaptation and mitigation.

The World Bank is taking a landscape approach in helping nations deal with climate change. However, to develop a better understanding of the issues, donor nations and others need to go directly to the public to determine what is needed and what is deemed important. Public dialogue is needed to understand what regional resilience and mitigation looks like, how to share the costs and benefits of both, and whether these actions may achieve the desired end

goals. For example, how might climate-change uncertainties affect choices, and what is the best plan for the greatest value?

4.7 Kimberly Pfeifer: Oxfam's Perspective on Climate Change and Global Food Security

Under changing climate, increases in extreme events globally and across the U.S. landscape and global disasters and need for emergency responses seem likely. Even with global efforts in place to reduce the numbers of poor and hungry in the world, climate change and the related outcomes will hit the hungry and impoverished particularly hard.

Oxfam focuses on a humanitarian relief and international development and has a goal of creating a world without poverty and injustice. From the USDA's technical report, Oxfam hopes to better understand the agency's thinking on and approaches to dealing with food security and climate resilience. In addition, the organization hopes to improve understanding of how climate change might affect food-price volatility, including if and how price spikes might be avoided, and who will likely win and lose in the market volatility resulting from changing climate.

Oxfam supports development of a broader set of tools to address food insecurity, and would be interested in seeing some of these issues taken up in the report. The organization also has interest in learning more about the effects of climate change on agricultural production in low-income countries, along with the plausibility of policy shifts in dealing with climate change-related crises. In addition, Oxfam sees benefit in the report covering how climate change will affect issues of nutrition, diet, and dietary behavior, globally and regionally, as well as providing some insights on the cascading effects of climate change on U.S. agricultural and food systems on the global market. Other questions of interest include understanding how nations might deal within the linked global food systems in the face of disaster, including addressing the trade-offs for increasing global linkages within the system and whether value exists in having viable exit options within the globally linked food system.

4.8 Diana Liverman: National Climate Assessment and Development Advisory Perspective (NCADAC)

Diana Liverman, a NCADAC member, noted that the 2013 U.S. National Climate Assessment (NCA) considered food security, however the report did not cover the topic within the context of the connections between regional, national, and global food systems. Inherently global in nature, regional-, national-, and global-scale food system interactions and operations are affected by what goes on in the rest of the world. The NCA's readers would benefit from content that includes this international perspective on the function of food system, food security, and the effects of climate change. Moreover, some of the world's biggest companies rely on global supply chains for their profitability; if other parts of the world suffer, it will affect U.S. exports, U.S. profits, and the nation's ability to do business. Connections between food insecure people and global and national supply chains, retail, and the corporate "bottom line" will affect decisions made both within the global and U.S. food industries, and by decision makers worldwide. Moreover, from a consumer point of view, the international food system affects local markets, with global food price increases causing related costs to rise in key consumer products. As a result, the international food system context provides a critical perspective that helps producers, decision makers, and consumers better understand future trends within the U.S. food system, as well as the effects of global-scale food security on the nation.

4.9 Bob Watson: The Role of the Assessment and Food Security Issues

Global food security is central to environmentally sustainable development. Food production must be economically, environmentally, and socially sustainable, but if global decision makers sacrifice current production for sustainability, the world will have more food insecure people instead of fewer. To achieve both sustainable development and food security will require identifying how to maximize the value of relevant ecosystem services, with some studies suggesting that a radical redesign of the global food system will be needed to achieve the desired ends.

Watson warns that just looking at agriculture and climate change is not enough. There is a need to think through natural climate variability and post-harvest loss.

Addressing hunger might be achieved with current technologies, with advanced biotech possibly used to address future productivity requirements – especially given the growing numbers of the global population whose incomes are rising. Future technologies might increasingly emphasize agro-ecological practices (e.g., no/low till, integrated pest management, and integrated natural resource management), coupled with decreased post-harvest losses and food waste. Advanced biotechnologies may be needed to address future demands for increased productivity and emerging issues such as climate change and new plant and animal pests, but the risks and benefits must be fully understood. Additionally, global agriculture could contribute less to climate change if farmers were paid to maintain and enhance ecosystem services.

In the next 20-50 years, a vibrant agricultural sector will be needed to feed the world, stimulate growth, and ensure equal access to food. Climate change that will occur through the 2030s is inevitable due to inertia in the climate system. With climate change mitigation, currently projected changes may be significantly reduced beyond that time. To respond to climate change, a need exists to integrate agriculture, economics, environment, and social sustainability into policies, practices, and technologies. The USDA report may benefit from incorporation of some or all of these considerations.

5.0 Scope: Climate Change, Global Food Security, and the U.S. Food System Report

To study some of the effects of climate change on global food security, and to better understand the cascading consequences of climate change and global food security on food systems, the USDA has tasked a team of authors from the Federal service, universities, and the international community to write a technical report. The report will begin by looking at areas of intersection between global food security and climate change. In addition to investigating the worldwide effects of climate change and food security, the report will consider the influence that these effects have on global and U.S. food systems; food systems include food production, transportation, storage, processing, etc. (see Box 3), as well as provision of food aid, and wholesale and retail trade.

The USDA technical report will explore how climate and food security interconnect globally, including economic feedbacks. Building from these initial explorations of cause, effect, and possible repercussions, the authors hope to generate scenarios that provide a sense of how these effects will play out over time in a changing climate.

Scenario development will consider the effects of future climate change and socio-economic development to help assess future food security 25 and 100 years in the future. Challenges abound in developing realistic scenarios. Considerations include the degree to which current technological conditions apply into the future, how scenarios include estimates of future climate change adaptation strategies and technologies such as different agricultural management techniques or new economic tools, and projections of future economic conditions.

This information will then be used to assess what these outcomes will mean for the global food system. With an understanding of how global food systems change under scenarios of changing climate and the related effects on global food security, the focus will return to U.S. food systems. The initial global viewpoint on food security and food systems will be essential given the degree to which international food system dynamics influence U.S. food systems, with effects ranging from costs of food and related products, to transportation and production logistics, to changes in demand.

Based on discussion at the workshop, the technical report is now anticipated to have four developmental sections. The first will explore current connections between global food security and climate change and the many ways in which the two areas intersect. Socioeconomic scenarios will be developed and discussed in the second section, providing analysis and tools to anticipate possible changes in food security outcomes due to climate change occurring in the next 25 and 100 years. The third section will analyze consequences for global food systems of the changes projected in the scenarios, and the final section will consider on the consequences for U.S. food systems.

Appendix A: Workshop Attendees

Peter Backlund
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and the Integrated Science Program
NCAR

Molly Brown
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NASA

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Geographer
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Economics Branch
USDA Economic Research Service, Food
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Jared Creason
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Greg Degen
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Christopher Delgado
Economics and Policy Adviser in the
Agriculture and Environmental
Services Department
World Bank

Bill Easterling
Dean of the College of Earth and
Mineral Sciences
The Pennsylvania State University

Rob Flynn
George Washington University

John Furlow
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Jerry Glover
Senior Sustainable Agricultural Systems
Advisor
USAid

Bill Hohenstein
Director
USDA Climate Change Program Office

Kathy Jacobs
Assistant Director for Climate
Adaptation and Assessment
OSTP, Energy and Environment Division

Jenna Jadin
AAAS Fellow/Advisor
USDA, Office of the Chief Scientist

Rick Leach
CEO
World Food Programme USA

Diana Liverman
NCADAC Committee Member;
Co-Director, Institute of the
Environment, University of Arizona;
and Visiting Professor and Senior
Research Fellow in the Environmental
Change Institute, Oxford University

Hector Maletta
Professor at the Graduate School of
Social Sciences
Universidad de Buenos Aires

Anthony Murray
Economist
USDA- Economic Research Service

Margaret Walsh
Ecologist
USDA Climate Change Program Office

Moffatt Ngugi
Program Analyst (Climate Change in
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USAid/USDA-Foreign Agricultural
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Robert Watson
Chief Scientific Advisor, UK Department
for Environment, Food and Rural
Affairs, Professor of Environmental
Sciences, University of East Anglia, and
Director of Strategic Development,
Tyndall Centre for Climate Change

Brian Peniston
Director, Himalaya Program
The Mountain Institute

Kimberly Pfeifer
Head of Research
Oxfam America

John Reilly
Senior Lecturer and Co-Director of the
Joint Program on the Science and
Policy of Global Change at the Center
for Environmental Policy Research MIT
Sloan School of Management

Ana Rios Galves
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Stacey Rosen
Agricultural Economist
USDA Economic Research Service

Martha Schlicher
Bioenergy Technology Lead
Monsanto Company

Claudia Tebaldi
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Prasad Thenkabail
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